Food safety and quality analysis at the point of care

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Food safety remains a critical issue today. According to the World Health Organization (WHO), approximately two billion people worldwide die from food poisoning caused by bacteria, viruses and parasites annually. These incidences have led to the efforts to develop analytical devices for food safety and quality control. Conventional food safety analytical technologies, including high performance liquid chromatography (HPLC), gas chromatography (GC), quantitative real time polymerase chain reaction (qPCR) and enzyme-linked immunosorbent assay (ELISA), are not only labor intensive and time-consuming, but also high-cost. In addition, most of the diagnostic tests are performed at well-established laboratories. However, resources in central laboratories are limited in developing countries where foodborne diseases are prevalent. Therefore, there seems to be an urgent need to create cost-effective and robust analytical devices for healthcare applications. Recent technological advances have made it possible to develop point-of-care (POC) devices, including chip-based and paper-based devices to rapidly diagnose diseases for providing lifesaving treatment in a timely manner.

Keywords: Point-of-care devices ; chip-based devices ; paper-based devices ; food safety and quality analysis

1. Introduction

With the advances in point-of-care (POC) testing, researchers have sought to develop microfluidic chip-based devices (*e.g.,* poly(methyl methacrylate) (PMMA)- or polydimethylsiloxane (PDMS)-based chips) and paper-based devices (*e.g.,* lateral flow test strips and three-dimensional paper-based microfluidic devices), which are fast gaining popularity for use in detecting food contaminants [1][2]. Chip-based devices enable precise control and manipulation of small amount of samples to achieve high throughput analysis. Recent advancement in microfluidic chips has precluded the need for external instruments such as benchtop detectors, computers and power supplies, reducing the overall cost and size of the devices[3].

Paper-based devices, especially lateral flow test strips and microfluidic paper-based analytical devices, have attracted significant scientific interest for food safety monitoring as they are simple, affordable, biodegradable and ease-of-fabrication, modification and functionalization [4][5]. Their fascinating properties have enabled rapid, on-site POC testing in remote settings with limited accessibility to laboratory infrastructure. Other devices such as nanomaterial-, thread-, cuvette-, tube-, disc-, glass slide- and well plate-based devices have also been developed for POC food safety analysis [6][7][8][9][10][11][12]. These devices were developed to improve the sensitivity and functionality of both paper- and chip-based devices, providing more promising options for real-life applications. These emerging technologies enable patients to perform onsite and home-based testing, allowing immediate access to healthcare information and prompt medical treatment at the POC [13].

2. challenges

While POC devices have been extensively studied, several challenges remained to be addressed before their translation into practical applications. To address these formidable challenges, ongoing efforts have been devoted to achieve sensitivity improvement, quantification, multiplexing and multi-functionality in POC food safety assessment [14]. For instance, signal amplification techniques were integrated into paper- and chip-based devices to enhance their analytical sensitivity such as silver enhancement technique [15] and dual labeling technique [16]. Some devices were coupled with smartphone-based readers to achieve the quantitative detection of foodborne pathogens and chemicals [17][18]. In addition, fabricating POC devices with the ability of multiplexed detection has also attracted considerable scientific interest, which could significantly reduce assay time and cost, thereby increasing assay productivity [19]. More recently, numerous groups have developed integrated sample-to-answer devices that incorporate multiple key processing steps such as sample preparation (*e.g.,* filtration, concentration and separation) and nucleic acid testing (NAT) steps (*e.g.,* nucleic acid extraction and amplification) into a single device prior to target detection [20]. The advent of these technologies has remarkably enhanced the functionality of POC device to achieve more effective food safety analysis and quality control.

Even though significant efforts have been devoted in this emerging field, there are several challenges that require attention. Future goals should focus on further simplifying the user steps by creating an automated fluidic delivery on chip as well as incorporating multiple steps into a single device (*e.g.,* nucleic acid extraction, amplification and detection) in a simple and cost-effective manner [14]. The ability of preserving all reagents on board is crucial to eradicate the need for laboratory storage unit and the capability of multiplexing could significantly improve the assay productivity [21]. Further, more studies should focus on developing more robust smartphone apps that allow on-site analysis while providing swift transfer and data storage to keep track of records. Given the fact that wireless network supply is limited in most resource-poor settings, the device should also be supported by asynchronous data transmission. The integration of alternative power sources such as battery or solar power would remarkably improve the performance of device especially in rural areas with limited power supply [22]. In addition, integrating all key processing steps (*e.g.,* sample collection, sample preparation and detection) into a single fully integrated device would significantly improve the device functionality.

Novel nanomaterials have been widely explored in the field of sensing and food safety applications. The benefits of using carbon-based nanomaterials [(*e.g.,* graphene and graphene oxide (GO)], noble metal nanoparticles [(*e.g.,* gold nanoparticles (AuNPs) and silver nanoparticles (AgNPs)] and molecularly imprinted polymers (MIPs) have also been frequently reported [23][24], especially the capabilities of producing enormous signal enhancement and amplification with high selectivity. Exploring new nanomaterials such as black phosphorus would be beneficial due to their fascinating properties such as direct bandgap, strong structural and functional anisotropy, high conductivity and electron transfer capacity [25], which could remarkably improve the detection sensitivity. In fact, better understanding of the fundamentals of these materials in terms of chemical, structural and physical properties would allow engineering of these materials to produce more biocompatible substrates. The stability of these materials should also be tested to ensure its robustness and reliability for real applications.

[1][2][3][4][5][6][7][8][9][10][11][12][13][14][15][16][17][18][19]

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